UNITED STATES DEPARTMENT OF AGRICULTURE

U.S. Agricultural Research Service

Third Annual
WHEAT UTILIZATION RESEARCH CONFERENCE

Northern and Western Utilization Research and Development Divisions
Crops Research Division
Millers' National Federation

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Mr. Persell was given the other copy, mlc

at Peoria, Illinois
September 30 - October 1, 1958

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

THIRD ANNUAL WHEAT UTILIZATION RESEARCH CONFERENCE

PROGRAM

ABSTRACTS OF REPORTS

RESEARCH SUGGESTIONS

DISCUSSIONS

Northern and Western Utilization Research and Development Divisions
Crops Research Division
Millers' National Federation

at
Peoria, Illinois
September 30 - October 1, 1958

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FOREWORD

The third annual Wheat Utilization Research Conference was held at the request of the Millers' National Federation in order to increase dissemination of information not only on research progress being made in the chemistry and technology of wheat and wheat products by the Department of Agriculture, but also on problems of current interest to the milling industry. In addition, it was intended to promote continued improvement in liaison between the milling administrators and technologists throughout the country and the wheat research personnel working in the utilization laboratories of the Agricultural Research Service, Department of Agriculture.

The following research agencies of the U. S. Department of Agriculture were represented at the Conference:

Agricultural Research Service:

Northern Utilization Research and Development Division
1815 North University Street
Peoria, Illinois

Western Utilization Research and Development Division
800 Buchanan Street
Albany 10, California

Crops Research Division
Beltsville, Maryland

State Experiment Stations Division
Washington, D. C.

Agricultural Marketing Service:

Grain Division
Beltsville, Maryland

State Agricultural Experiment Stations represented:

Kansas Agricultural Experiment Station
Manhattan, Kansas

(over)

State wheat organizations represented:

Colorado Wheat Administrative Committee
1636 Welton Street
Denver, Colorado

Kansas Wheat Commission
201 West First Street
Hutchinson, Kansas

Nebraska Wheat Commission
606 Trust Building
Lincoln, Nebraska

Washington Wheat Commission
409 Empire State Building
Spokane, Washington

SUMMARY OF CONFERENCE

Significant advances in cereal chemistry and processing, and important trends in the milling and baking industries ably reported at this third yearly meeting gave participants an encouraging cross-section of current progress and developments in the wheat utilization field. Presentations on the Government's program for wheat quality evaluation and on its present over-all approach to utilization research on cereal grains broadened the scope and value of the two-day agenda.

Fundamental Research: Among important fundamental findings reported by utilization research concerning wheat constituents was the chromatographic separation of gluten into four major components, obtained in distinct, reproducible fractions of high purity. Prior electrophoretic studies of gluten had shown existence of these four principal components, as well as one additional in minor amount. Availability of clear-cut gluten protein fractions will, through their further study by established techniques, contribute to knowledge leading to better and greater utilization of wheat gluten. Also reported was the separation of individual albumin protein components from flour, with amounts of purified components expected to be sufficient for chemical characterization and baking studies. Purity of the gliadin component obtained is adequate for food or commercial use.

Processing: Use of an improved continuous process for converting wheat flour into gluten, starch, and a soluble fraction, followed by a new and simple drying procedure for recovering the vital gluten, reported by utilization research, provides a commercially feasible combination for obtaining useful products for industrial food, or other special uses. The soluble fraction, containing proteins, and sugars, could find use as a nutritional adjunct to fermentation media. Potential uses for chemically modified forms of wheat flour were discussed and demonstrated during the laboratory tour. Studies reported on the wheat malting process indicated that variation in malting and kilning conditions has parallel effect on alpha-amylase and protease activities in the product, thus development of a more favorable ratio of protease enzyme seems impracticable.

Milling: Physical and chemical properties of various fractions obtained by air classification of wheat flours, and their significance, were described by the milling industry's representative. A practical physical subdivision is possible of both hard and soft wheat flours to produce fractions which, alone or in combination, are as valuable as the parent flour. Potential influence of this new and important milling procedure on the milling and baking industries, and on other possible modes of wheat utilization was pointed out. In Northern Division studies designed to provide a background for conditioning research, several methods for determining penetration of moisture in the tempered wheat kernel were investigated. Water was observed to enter the

endosperm first around the germ, next at the brush end, and then from all sides. Progress on the several milling quality tests under study by utilization research, involving separately, cell-wall thickness, water take-up, compressibility, tissue staining, and acid-extractable pentosans, was reviewed, as was the status and general nature of the wheat conditioning literature survey.

Baking and Bakery Products: Fundamental work reported by utilization research relating to quality of bakery products and to baking included studies of bread staling, frozen preservation of baked goods, freshly baked bread aroma, soft wheat flour lipids and influence of sufhydryl groups on mixing behavior. Several years' study on the firming of bread during staling showed two additive factors responsible--the development of a more crystalline phase in the starch and the loss of moisture from the starch component to gluten. Differences in flour lipids appear not to be responsible for differences in cookie-spread characteristics of soft wheat flours. Among production features in the baking industry's move to greater economy, as reported by its representative, are the liquid ferment and continuous mix processes for bread which provide savings in time, labor, floor space and ingredients. The trend is toward less wheat flour in the bread formula.

Quick-cooking traditional types of bulgur, and canned, pre-cooked, whole-grain bulgurs from soft wheats developed by the Western Division were discussed and demonstrated as new wheat foods to stimulate consumption.

Suggested Research: Emphasis of wheat research suggested in the discussion period was on fundamental information related to practical problems of milling and baking. Conditioning research should be intensified; continue studies of gluten structure and the role of lipids and minor constituents; determine true basis for baking behavior differences in flours, leading to a quick, simple evaluation of quality in numerical terms. Additional effort is needed to establish nutritional value of white bread, and why wheat byproduct feeds do not give better growth response in animals. New, highly palatable wheat foods are needed to compete with nonwheat foods. Potential of new air-classified flour fractions for industrial use should be investigated. State wheat grower groups, represented for the first time, are seeking appropriate utilization research projects to support.

The conference ended on the general note that this annual series of meetings will be continued, so as to foster cooperation and exchange of information between the milling and baking industries and Government research, with the dual aim of expediting solution of practical problems in processing and of advancing utilization of wheat as a source of food, feed, and industrial products of value.

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

Northern and Western Utilization Research and Development Divisions
Crops Research Division
Technical Advisory Committee, Millers' National Federation

THIRD ANNUAL WHEAT UTILIZATION RESEARCH CONFERENCE at Peoria, Illinois September 30 - October 1, 1958

Agenda

9:00	Registration

September 30 -- Morning Session - W. D. Maclay, Director, Northern Division - Presiding

9:30	Welcome and Introductions
9:45	Response H. H. Schopmeyer, Chairman, Technical Advisory Committee, Millers' National Federation
10:00	Cereal Grains Research Program of the Northern Division F. R. Senti, Chief Cereal Crops Laboratory, Northern Division
10:25	Relationship of Selected Kernel Properties to Milling Quality of Soft Winter Wheats R. A. Popham, Ohio State University (Reported by M. M. MacMasters, Northern Division)
10:50	Recess
11:05	The Bread Staling Problem: Transfer of Moisture between the Starch and Gluten Components of Bread N. W. Taylor, Northern Division
11:30	The Bread Staling Problem: Effect of Starch Structure on the Firmness of Bread Crumb H. F. Zobel, Northern Division
11:55	Group Photograph (assemble at building entrance)
12:10	Luncheon

Afternoon Session - C. E. Rist, Assistant Director, Northern Division - Presiding

2:00	Progress Report on Other Wheat Research Projects of the Western Division J. W. Pence, Western Division
2:25	Chemical Compounds Associated with the Aroma of Freshly Baked Bread I. H. Hunter Field Crops Laboratory, Western Division
2:50	Flour Components that Affect the Spread Behavior of Sugar Cookies D. K. Mecham, Western Division
3:15	Recess
3:30	Progress Report on the Survey of Literature on Wheat Conditioning M. M. MacMasters, Northern Division
3:55	Preliminary Report on Methods for Determining Moisture Distribution in Wheat Kernel M. J. Wolf, Northern Division

October 1 -- Morning Session - H. H. Schopmeyer, Chairman, Technical Advisory Committee - Presiding

9:00	Current Developments in the Baking Industry R. B. Meckel, International Milling Company
9:30	Current Developments in the Wheat Flour Milling Industry S. J. Loska, The Pillsbury Company
10:00	General Discussion
11:00	Recess
11:15	Wheat Variety Quality Evaluation Studies L. P. Reitz, Crops Research Division
11:50	Effect of Variety and Malting Conditions on α-amylase and Protease of Malted Wheat J. A. Johnson, Kansas State College
12:15	Luncheon

Afternoon Session - F. R. Senti, Chief, Cereal Crops Laboratory, Northern Division - Presiding

2:00 Electrophoretic Analysis of Wheat Gluten
R. W. Jones, Northern Division

2:25 Chromatographic Separation of Proteins in Wheat Gluten
J. H. Woychik, Northern Division

2:50 Improved Processing Methods for the Fractionation of Wheat Flour and the Manufacture of Vital Gluten
Roy A. Anderson, Northern Division

3:15 Recess

3:30 Tour of Laboratories

Stations:

1. Composition and Structure Analyses Using Radioactive Carbon and Tritium
   J. C. Cowan, Northern Division

2. Cereal Product Developments: Canned Bulgurs, Pilafs, Frozen Batters
   J. W. Pence, Western Division

3. Electrophoretic Analysis of Gluten and Its Fractions
   N. W. Taylor, Northern Division

4. Chemical Modification of Wheat Flour
   C. R. Russell, Northern Division

WELCOME AND OPENING REMARKS

W. Dayton Maclay, Director
Northern Utilization Research and Development Division

We are glad to welcome again the members of MNF and their guests from the allied groups here at the Northern Division for this Third Annual Wheat Utilization Research Conference. We are pleased to have with us the representatives of four State wheat organizations, and members from the U. S. Department of Agriculture and the Kansas Agricultural Experiment Station.

It may be helpful, especially for newcomers, to outline areas of grain utilization research assigned to the Northern and Western Divisions. All investigations on corn, oats, grain sorghums, and rye are the Northern Division's responsibility. Industrial utilization and processing research on all grains, including work on wheat tempering and milling, is also the Northern Division's assignment. Food research on wheat, as well as all feed research on wheat and barley, except that involving fermentation studies, is the Western Division's responsibility. Both Divisions conduct fundamental studies on wheat and other grains, directed primarily toward their respective assigned research responsibilities.

Public Law 480 is providing a means of expanding USDA's utilization research program into foreign laboratories. P. L. 480 allows disposal of surplus agricultural products in foreign countries in exchange for local currencies to be spent within those countries. During fiscal year 1958, ending last June 30, $1 to $1.5 million was set aside for utilization research, under contract, in P. L. 480 countries that are capable of conducting such research. During the current fiscal year, $5 million more has been allocated. An additional $3.9 million has been assigned to USDA for cooperative farm, forestry, and marketing research, making a total of about $10 million of P. L. 480 funds already committed to USDA research abroad. Utilization research carried on under P. L. 480 will supplement work of the four regional utilization laboratories.

This past session of Congress saw Senate bill 4100, which embodies many of the recommendations for expanded utilization research made by the recent national Commission for Increased Industrial Use of Agricultural Products, pass the Senate. The House Committee on Agriculture considered Senate bill 4100 and related bills but did not bring them before the House. The general feeling is that some legislation may come out later along this line. There appears to be a growing over-all interest and appreciation, both in Government and in industrial circles, of the importance of utilization research, industrial-use research in particular. It is expected that interest will continued to expand, with corresponding strengthening and support of the utilization research program in agriculture.

RESPONSE

H. H. Schopmeyer
International Milling Company

On behalf of the Millers' National Federation and their guests, I wish to assure our hosts that we are glad to take part in this Third Annual Wheat Utilization Research Conference. The fact that this is the third such meeting is evidence of our interest in the wheat research program and the value we place on it for the milling and allied groups. Holding these meetings as an annual occurrence gives industry a chance to air its problems and to review research progress.

Need of the industry for such meetings was ably expressed by Mr. Atherton Bean, President, International Milling Company at last year's meeting. Research needs of the milling and baking industries were highlighted also by John P. Snyder, Jr., The Pillsbury Company, at the American Association of Cereal Chemists' meeting in Cincinnati last April. There are areas of ignorance in cereal chemistry. There is need for more basic information to help in developing much needed methods for flour evaluation, and in answering many of the technical questions still existing in the milling and baking industries.

To strengthen the Federation's liaison with the utilization research program of the Department, a resolution was recently passed calling for closer cooperation between the MNF Technical Committee and the Utilization Research Divisions.

Mr. C. L. Mast, Secretary-Treasurer for MNF, who is attending these meetings for the first time, is here with Mr. Herman Steen. Mr. Mast will take over the helm of MNF as Executive Vice President upon Mr. Steen's retirement. Mr. Mast will be looking forward to working with those of you in industry and in research.

CEREAL GRAINS RESEARCH PROGRAM OF THE NORTHERN DIVISION

F. R. Senti
Northern Utilization Research and Development Division

Because of the grain surpluses which have existed for the past several years, principal emphasis in our program has been on research directed toward increased industrial use of grains. Lesser emphasis has been placed on feed uses of grains; little or no work is currently in progress on direct food uses from the standpoint of product development.

Our research on grain utilization includes both product and process development. This work is supported by a program of more basic studies aimed at discovery of physical properties and chemical reactions which will be the basis for new or improved products and processes.

Principal areas of our utilization research on cereal grains are:

1. Product development

    a. Chemical modification of grain constituents.

    b. Genetic modification of grains. Work is cooperative with the plant breeder.

    c. Fermentative conversion.

2. Improved processing

3. Fundamental studies

Lines of work to develop new products through chemical modification:

1. Dialdehyde starch

    a. Pilot-plant process development. Engineering studies are in progress on development of practical and economic electrolytic processes for oxidation of starch to the dialdehyde form.

    b. Evaluation studies. Promising results have been obtained in a number of applications. We are planning a pilot-plant-scale evaluation of tanning properties for heavy leather.

2. Dicarboxyl starch. A starch with superior thickening properties, now ready for evaluation studies. It is made by oxidation of dialdehyde starch.

3. Chemical intermediates from dialdehyde starch. A variety of low molecular weight organic compounds are produced from

dialdehyde starch by reaction with various agents. We are investigating conditions for producing glyoxal and erythrose.

*4. Chemical modification of wheat flour.

5. Chemical modification of wheat gluten.

6. New polymers from fermentation acids. Among the great number of organic acids than can be produced by fermentation of cereal starch are the unsaturated acids such as itaconic and fumeric. These acids can be developed into plastics with interesting properties. This work is being conducted under contract at the University of Illinois.

<u>Lines of work to develop new products through genetic modification:</u>

1. High-amylose corn starch

   a. Analytical program. An extensive collaborative program with the ARS corn breeders and a private corn breeder on development of corn varieties which yield starch containing more of the amylose component than ordinary starch. Our role is to guide the breeder through chemical analyses of breeding samples.

   b. Wet-milling studies. Investigation of the wet-milling properties of high-amylose corn to determine starch-separation efficiency.

   c. Chemical modification. Chemical modification of the starch to improve its dispersion properties is being investigated.

   d. Film and fiber formation. High-amylose starches are desirable because amylose has good film and fiber-forming properties.

2. Increased vitamins and amino acids in oats. In collaboration with plant breeders, we have shown that the vitamins niacin and riboflavin can be controlled genetically. Similar studies are under way on the amino acid, lysine.

3. Increased xanthophyll in corn. We plan to survey a number of varieties to determine whether there is any varietal dependence of xanthophyll content and thus a basis for genetic improvement. More xanthophylls would improve corn's value as a broiler feed because they give the desirable yellow coloring to the skin of chickens.

<u>Lines of work to develop new products by fermentative conversion:</u>

1. Microbial polysaccharides from starch. Objective is to convert starch, degraded starches, or glucose from starch, by action of

microorganisms, to new types of polymers which have properties different from starch with potential new uses.

2. Beta-carotene. Process has been worked out for producing beta-carotene in good yields from a substrate comprised of a mixture of cereal grain and soybean materials.

3. Xanthophylls.

4. Microbial proteins for feeds. Search for a fermentation process using cereal grains which will produce one or more of the essential amino acids, lysine, methionine, and tryptophane to improve nutritional value of the grain. Two promising microorganisms have been found.

5. Microbial rubber. Certain mushroom-like fungi are known producers of rubber latex. A project to produce natural rubber in submerged cultures is in the exploratory stages.

6. Plant antibiotics. Work is in cooperation with plant disease people of ARS who screen various antibiotics produced by different microorganisms for effectiveness. One antibiotic preparation, F-17, has been found to have good anti-bean-rust factors.

<u>Lines of research for improved processing:</u>

1. Milling

   *a. Wheat conditioning

      Literature survey. A survey of the status of the applied art and existing knowledge in the field has been completed and is being prepared for the printer.

      Migration of water in kernel. Methods are being developed for following migration of moisture in the tempered wheat kernel.

   *b. Relationship of kernel properties to milling quality.

   c. Improved milling methods.

*2. Wheat malting. Studies carried out under contract with the Kansas State College to determine the effect of various processing variables and wheat variety on the quality as determined by proteolytic and amylolytic activities.

*3. Batter process for separation of wheat starch and gluten.

Fundamental studies in cereal grain research program:

1. Composition

Minor constituents of wheat, corn sorghum and barley. Non-saponifiable compounds of nonflour fraction of wheat; non-protein nitrogenous compounds of corn, including possible pellagra-producing substances; yellow pigments in yellow endosperm varieties of sorghum; and organic acids in barley.

*2. Gluten proteins of wheat

a. Electrophoretic analysis.

b. Chromatographic separation.

c. Properties of components.

3. Proteins of corn

Methods for analysis and separation.

4. Starch

a. Physical properties. Wetting properties of films relating to adhesion; molecular configuration of amylose in solution; molecular configuration of dialdehyde starch and kinetics of its degradation in alkaline solution.

b. Chemical reactions. Reactions of starch and dextrose with new reagents, using nonaqueous solvents.

5. Microorganisms

a. Exploratory studies of new chemical reactions which can be carried out by microorganisms, and of products which can be formed.

b. ARS Culture Collection. Taxonomy of yeasts, molds and bacteria.

c. Microbiological Pioneering Laboratory. Basic information on the chemical pathways or mechanisms by which these lower forms of life convert one organic compound into another, as a lead to better exploitation of microorganisms by the fermentation industry.

* More detailed discussions to be given by other NU speakers on the program.

RELATIONSHIP OF SELECTED KERNEL PROPERTIES TO MILLING QUALITY OF SOFT WINTER WHEAT

M. M. MacMasters
Northern Utilization Research and Development Division

Considerable progress has been made on the milling quality study at the Ohio State University by Dr. R. A. Popham, under contract from the Northern Division. Three manuscripts on earlier phases of the work have been prepared and approved for publication in CEREAL CHEMISTRY. These are:

Relationship between physical characteristics of kernels and milling score of soft wheat varieties.

I. Thickness of endosperm cell walls.
Richard A. Popham and Richard H. Eyde

II. Imbibition of water.
Richard A. Popham and Richard H. Eyde

III. Resistance to compression.
Richard A. Popham, Richard J. Naskali and P. C. Huang

In addition, studies have been made to determine if a rapid compression test might be developed to estimate milling quality of soft wheats. A motor-operated, unconfined compression machine was used to determine force required to barely crack individual kernels. Each test sample consisted of 50 kernels. Blackhawk, Wabash, Kawvale, American Banner, Trumbull, Thorne, Clarkan and Fairfield varieties of the 1955 crop and these varieties plus Butler and Lucas varieties of the 1956 and 1957 crops were tested.

Tests were made on undried kernels (as stored), and on kernels dried for 1 week at 55° C., for 2 weeks at 55° C., and for 6 hours at 100° C. Drying for 1 week at 55° C. was concluded to be suitable. Compression test data from kernels so dried correlated as well with Seeborg milling scores of the varieties as those from kernels dried 2 weeks. Drying for 6 hours at 100° C. led to poorer results.

Compression test values gave a more stable ranking of the varieties from year to year than was obtained from the Seeborg milling scores. Clarkan variety gave no correlation between compression test value and Seeborg milling score. The other varieties showed correlation to 0.05 significance levels between the annual compression force data and the 5-year mean Seeborg milling scores.

The effect of protein content on the compression force required to crack the kernels is now being investigated.

Another phase of the milling quality study is the investigation of stains and reagents that can be applied to kernel tissues under the microscope to determine differences that may be correlated with milling quality. The following have been used, either alone or in combinations, often by various methods of application: Safranin, Fast Green, Anilin Blue, Chlorazol Black E, Bismarck Brown Y, Iodine Green, Methyl Violet, Orange G, Acridine Red, Thionin, and Phloroglucinol-HCl (cold). Several of the histochemical tests investigated showed either qualitative or quantitative differences when applied to Blackhawk (good milling), Trumbull (intermediate), and Fairfield (poor milling) varieties. Further work along these lines is contemplated. It is hoped that a quick field test for millability may be developed. Such a test would require only cutting the kernel open, applying the stain or reagent, allowing a short time for color development, and estimating milling quality from the result.

MOISTURE SORPTION OF WHEAT STARCH AND GLUTEN IN RELATION TO BREAD STALING

N. W. Taylor
Northern Utilization Research and Development Division

A major physical change occurring in staling of bread is considered to be the retrogradation of the starch component. Alteration in water-absorbing power of the starch component during staling might be expected to cause transfer of water to the gluten with a further change in physical properties. These possibilities were investigated by sorption measurements under high humidity conditions comparable to those in bread (near 97 percent). Water absorptions of heat-gelatinized wheat starch and of heated wet gluten preparations were observed in this high humidity range as a function of time. The starch gels decreased in water-absorbing capacity with time, whereas the gluten appeared to remain constant in absorbing capacity. These observations indicate that there should be a small but definite transfer of water from starch to gluten during staling of bread. Studies on the mechanical properties of starch gels indicate that the firming of starch resulting from this transfer should be small compared to the firmness changes caused by crystallization of the starch.

EFFECT OF STARCH STRUCTURE ON FIRMNESS OF BREAD CRUMB IN STALING

H. F. Zobel
Northern Utilization Research and Development Division

Firmness of bread crumb is used by the housewife as well as the scientist to judge freshness of bread. Changes in crumb structure begin with cooling of the bread and proceed rapidly for the first 24 hours after baking. In that time, firmness values may double. While crumb firmness increases, other factors like swelling power, amount of water solubles, and susceptibility to the action of enzymes decrease indicating a process akin to insolubilization is taking place in the crumb structure. Working with isolated starch gels one finds that identical relationships hold. The effects described are usually attributed to starch retrogradation, a term for the spontaneous insolubilization of starch. It is generally recognized that changes in the starch component of bread cause some of the major changes included in the term "staling."

A special type of starch retrogradation is that of crystallization, in which case the retrograded particles are large enough to reflect X-rays and give diffraction patterns. Katz was the first to show that the X-ray diffraction pattern of fresh bread was similar to that of freshly gelatinized wheat starch, whereas the pattern for stale bread was similar to that of a highly retrograded starch. Patterns of retrograded starch were characterized by an increased number of lines, indicating that part of the starch had crystallized during retrogradation.

A partially crystalline, highly polymeric material like starch is viewed as having a network of crystalline and amorphous regions. A given polymer chain may pass through several crystalline regions; also, a given crystalline region may be linked by several polymer chains to other crystalline regions. Crystalline regions thus serve as tie-points to restrict the movement of polymer chains when subjected to stress and in this manner contribute to rigidity of the polymer structure. Because the elastic moduli of high polymeric materials generally increase with the extent of crystallization, it may be reasoned that the firming of bread crumb which occurs during staling results from crystallization of the starch phase.

Typical firming values for a wheat starch bread are 2.2 to 13.3 (gms. per sq. in. for a 2.5 mm. depression) when measured at room temperature (R.T.) from 2 to 140 hours after baking. If one substitutes a cross-linked corn starch for 40 percent of the wheat starch, the firmness values are 5.4 and 20.3, respectively. X-ray patterns taken at comparable time periods show corresponding increase in crystallinity with increased firmness. On the basis that cross-linked corn starch gels had shown more apparent crystallinity

than comparable wheat starch gels, the greater firmness in breads with the modified starch can be accounted for. Several workers have determined that breads firm less if held at elevated temperatures (40 to 50° C.) and that if held at temperatures near 2° C. the bread becomes unusually firm. Breads stored at 2 to 4° C. temperatures, where starch retrogradation is known to be accelerated, give sharp X-ray patterns showing increased crystallinity over R.T. stored breads. At temperatures greater than R.T., X-ray patterns indicate that less crystallization takes place. Often a firm bread may be softened and thus regain acceptance if heated under conditions that prevent loss of moisture. Here also, crystallinity is lost and the X-ray pattern may be typical of an oven-fresh bread. The extent of this conversion is highly dependent upon sufficient water being present.

With crystallization thus a major cause in firming breads, what approaches are there to this bread staling problem? Three may be suggested: Use of noncrystallizing materials, inhibiting starch crystallization, and nullifying the effects of crystallization.

The first approach would require modified flours or flour derivatives. Crystallization would perhaps not be completely eliminated but at best decreased. A cross-linked wheat flour might serve this purpose, since cross linking decreases considerably the rate of crystallization of corn starch gels. Inhibition of crystallization is rather difficult. Katz had some favorable results, but with objectionable chemicals like aldehydes. A simple chemical like water will aid in this respect but other factors limit the amount that can be incorporated.

Thirdly, one can nullify the effects of crystallinity. Numerous workers have shown the effectiveness of added enzymes in retarding staling, but without corresponding studies on starch crystallization. Bechtel added a heat-stable alpha-amylase to breads made with reconstituted flours; certain of these breads were studied at the Northern Division. Addition of 24 SKB units of enzyme resulted in the maintenance of bread softness for at least 140 hours after baking. The breads, however, showed no apparent decrease in crystallinity of the starch component. Working with isolated starch gels it was determined that incorporation of enzyme could even cause crystallinity to be accelerated.

Action of the enzyme in nullifying crystallization effects is best seen by referring to the picture presented earlier of the crystalline-amorphous network in the starch polymer. Hydrolytic cleavage of the starch chains by bacterial alpha-amylase would be expected to occur preferentially in the amorphous regions because here the structure is most open and accessible to attack. Scission of chains in these regions, obviously, would tend to free the structure of restraints imposed by the crystalline regions. Such chain scission in the amorphous regions would give the crystallites

greater freedom to move independently of one another, with a resulting decrease in rigidity of the system. This effect would be most marked at high moisture conditions where slippage of starch molecules past each other is facilitated by the plasticizing action of the water molecules.

Discussion:

Dr. Senti, in discussing further the results covered in Dr. Taylor's and Mr. Zobel's presentations, pointed out that a major question in this staling study was the relative contributions of starch crystallization and of loss of water from starch to the firming of this component in aging bread. Water acts as a plasticizer for starch, just as it does in cellulose, by lubricating motion of molecules past one another, thereby reducing stiffness of films of starch or cellulose.

We know that starch in water dispersions loses its water-holding capacity on standing, as evidenced by formation of aggregates of starch molecules in solution which ultimately precipitate. In this process, water molecules surrounding starch molecules are replaced by those of starch due to the greater attraction of starch for starch.

Main constituents in bread are starch and protein. During baking, starch granules open up and absorb much more water than unmodified granules. This transforms wet dough to a dry crumb with very little loss of total moisture from the system. Gluten does not change much in moisture-holding capacity during simulated baking. Dr. Taylor's results indicate that a small but definite transfer of moisture should take place between these two components, the starch losing about 1 percent. Measurements on the mechanical properties of starch gels as a function of moisture content indicate that increase in bread firmness caused by transfer of 1 percent moisture is less than the increase in firmness resulting from the crystallization process described by Mr. Zobel.

The question was raised whether amylopectin (branched-type starch) or wheat containing waxy starch (amylopectin) could be used as a means of avoiding or minimizing bread staling. It was pointed out that amylopectin also tends to crystallize to about the same degree as ordinary starch; however, it does so more slowly. What might be useful would be a more highly branched form of starch similar to glycogen which does not crystallize.

No waxy-type wheat has been discovered, but it might be worthwhile for plant breeders to look for it in connection with plant exploration work. If a waxy wheat could be found, it could be expected to produce flour with unusual properties.

Incorporation of monoglycerides in bread causes some changes in the X-ray pattern.

PROGRESS REPORT ON WHEAT RESEARCH PROJECTS OF THE WESTERN DIVISION

James W. Pence
Western Utilization Research and Development Division

A major area of emphasis in the wheat research program at the Western Division is study of methods to improve freshness and palatability of baked foods at the time of purchase and consumption. Projects on bread flavor (see page 22) and freezing of bakery products fall into this category. Freezing by proper methods immediately after baking is the only known means whereby a substantial degree of the original quality of freshly baked products can be preserved for more than a few days. Where distribution and sale of strictly fresh merchandise is not possible, suitable freezing procedures can be used to provide merchandise of better eating quality than otherwise possible. Research has shown that cakes generally are less sensitive than bread items to variations in freezing practices. Frozen cakes held for many weeks are still generally superior to cakes held for 24 hours at room temperature. In time, however, cakes deteriorate seriously in frozen storage. Best results are obtained when cakes are held in storage between 0° and -10° F. A cooperative study with the Agricultural Marketing Service and several private enterprises is being started to determine the most feasible application of freezing to various types of bakery operations from the standpoint of cost and possible economic advantage.

Other efforts to promote increased consumption of wheat foods include the development of quick-cooking traditional types of bulgur and canned, pre-cooked, whole-grain bulgurs from soft white wheats. Besides these basic products, canned and ready-to-eat dishes, such as pilafs, poultry stuffings, cereal and meat combinations, etc., are promising possibilities.

Additional information has been obtained to support the postulate that sulfhydryl groups in flour proteins influence the mixing behavior of flours by means of a sulfhydryl-disulfide radical interchange mechanism. Flour fractionating and reconstitution experiments using sulfhydryl-blocking agents showed that the sulfhydryl groups in gluten, rather than those in other fractions, influence mixing characteristics. During the mixing of doughs, sulfhydryl-group contents fall rapidly during early stages but tend to level off at just below half of their original values as mixing is continued well into the breakdown phase.

After much unsuccessul effort with a wide variety of methods, separations of individual albumin protein components of flour are being achieved with ion-exchange cellulose derivatives. Amounts of purified components sufficient for baking and chemical characterization experiments are currently being accumulated. Methods using new extraction media and adsorption techniques are being developed for economical preparation of gliadin for commerical usage. Aqueous tertiary-butyl alcohol extraction followed by adsorption of impurities on carbon black produce gliadins of sufficient purity for commercial food and industrial use.

Early results from a comprehensive study of the relationship between acid-extractable pentosans of western white wheats and their milling quality suggest that high correlations, found earlier in limited comparisons, will be confirmed. More than 200 samples each of spring and winter wheats are being examined. Several hundred samples resulting from two crosses and subsequent backcrosses are being used to follow the heritability of factors affecting milling quality and pentosans content.

CHEMICAL COMPOUNDS ASSOCIATED WITH AROMA OF FRESHLY BAKED BREAD

Irving R. Hunter
Western Utilization Research and Development Division

The decrease in recent years in per capita consumption of wheat products, particularly bread, indicates, among other things, consumer dissatisfaction with flavor and palatability of bread sold today. Development of methods to improve flavor and quality of bread are worthy objectives of research and, logically, they must start with identification and measurement of the compounds responsible for this flavor. Work has been initiated at the Western Division on the development and utilization of new methods, and modification of existing ones, for bread flavor work.

A study of flavor must progress through a certain number of definite stages before knowledge of the individual compounds involved can be obtained. These stages are collection, concentration, separation and identification.

Bread flavors were collected by condensation of volatile material distilled from bread during baking and by adsorption on charcoal of material emanating from hot freshly baked bread. Another method of collecting a sample of bread flavor was by means of extraction of bread with two types of solvents, water and methylene chloride. Both solvents have their advantages and disadvantages. Other techniques used were steam-distillation of freshly baked bread and the preparation and study of a pre-ferment type brew in order to study compounds introduced in the dough by fermentation.

At the present time, upwards of forty different chemical compounds have been isolated from bread by workers at the Western Division and other laboratories over the country. Identity of some of these compounds is still indefinite but most have been positively identified. Included in the group are substances from the following types of compounds: Acids, alcohols, esters, and carbonyl compounds, such as aldehydes and ketones. Some are complex compounds, such as keto acids. Basic compounds, probably amines, have been shown to be present, but no individual compounds have yet been identified.

Little is yet established about the origin of these compounds, but it is known that both fermentation and baking are necessary for full flavor development in bread. Probably both agencies contribute to the list of compounds thus far identified as taking part in bread flavor and aroma.

Gas chromatography has proven to be an effective tool in flavor work with bread. The new argon ionization detector, capable of detecting as little as one part of a component in 10^8 parts of

carrier gas (argon) is a further important addition to the instruments available for this type of work.

Discussion:

Western Division's bread flavor work is at too early a stage to arrive at isolation of individual compounds or a combination of compounds which give characteristic odors of fresh bread. Among factors posing difficulties are very low relative concentrations of flavor and odor components, and their possible chemical interaction before isolation can be accomplished. There is the possibility that heat of the oven in baking is responsible for certain end reactions which account for the freshly-baked odor. Work is just starting on the amine-type compounds; these exhibit an odor characteristic of cereal products. No flavor studies have been made on gluten or starch baked alone.

Gas chromatography is more sensitive for flavor work than infrared according to the Western Division. It can detect at a level as low as 1 part per million. Facility of the method is limited by the many flavor factors present, necessitating separation of mixtures into classes or groups prior to gas chromatography. The main identification criterion thus far has been effluent time. Quantitative determination of compounds is made by burning to CO_2 and measuring the CO_2 formed.

American Institute of Baking has started on bread flavor work. Flavor components are obtained by vacuum distillation of bread from a retort heated externally by steam. Oxidative changes are avoided by use of vacuum. Moisture and flavor materials are drawn off and condensed in cold traps. Ultraviolet absorption and gas chromatography are among techniques used in investigating the flavor factors. For some compounds, no methods are available as yet for quantitative determination. Different classes of compounds are separated by ion-exchange procedures. The carboxyl compounds (acids) obtained have an obnoxious odor. Carbonyl fractions, however, have a bread-like odor.

Kansas State College is studying flavor factors in bread in connection with its investigation of pre-ferments used in baking.

FLOUR COMPONENTS THAT AFFECT THE SPREAD BEHAVIOR OF SUGAR COOKIES

Dale K. Mecham
Western Utilization Research and Development Division

As part of studies at the Western Division on relationships of the composition of flours to their baking and other properties, some cookie-baking work has been carried out to determine whether flour lipids may have an effect on the cookie-baking properties of flours. The basis for this work lies in the repeated reports that flour lipids modify the bread-baking behavior of flours. The lipid effects appear to be exerted through combination with proteins in many respects, but independently of protein in other respects. Because nearly all recorded observations on lipid effects were concerned with hard wheat flours and bread baking, we were interested in determining what results might be found with a different product baked from soft wheat flours by much different procedures. Accordingly a sugar-cookie baking test was used; it provides marked contrast to bread-baking procedures in water, fat, and sugar contents and pH of the dough, in dough-mixing treatment, and lack of fermentation.

Comparisons were made of the cookie-baking behavior of untreated flours; of flours extracted with petroleum ether, with carbon tetrachloride, or with n-butyl alcohol saturated with water; and of the extracted flours to which the extracted material was restored. Removal of lipids by petroleum ether or carbon tetrachloride had little effect on cookie spread; the more complete removal of lipids by water-saturated n-butyl alcohol decreased spread markedly. Restoration of extracted material restored the original properties.

By interchange of the material extracted by water-saturated n-butyl alcohol between two flours of markedly different spread characteristics but nearly equal protein content, it appeared that differences between flours were not attributable to differences in the lipids. Further observations suggested an explanation, in that restoration of only about one-third the extracted material restored cookie properties. The liklihood, therefore, of flours being deficient in the necessary lipids appears small.

From the standpoint of understanding changes that occur in the baking process, however, it was of interest to determine which flour lipids were effective and whether other lipids, not from a flour source, could be found to have the same effects. On the basis of observations made to the present, several phospholipid fractions from flour, and other vegetable phospholipids, are fairly effective in restoring cookie spread to extracted flours. A trial of several emulsifiers showed that a sucrose fatty acid ester also could restore a considerable part of the spread.

The results suggest that study of effects of lipids on protein denaturation, starch gelatinization, and other processes occurring during baking would be generally useful in understanding differences in baking behavior of flours in a variety of products, as well as the effects of formula variations on product quality.

Discussion:

Several points were raised concerning possible further observations that might have been made in the cookie-spread work with soft wheat flour lipids. The Western Division studies so far have not included determination of:

Whether spread of poor cookies could be increased by addition of lipids from a flour which gives good cookie spread.

Whether additional lipid obtained by extraction with butanol after carbon tetrachloride extraction was different from a lipid extracted by carbon tetrachloride alone.

Effects on cookie-spread results using unbleached soft wheat flours.

Comments from the discussion group included the observations:

Phosphatides might be expected to have a role in cookie-spread.

Percent phosphatide in the lipids from patent flour is high, although the total fat content of the flour is low.

Other factors besides lipid content may be involved in the cookie-spread results because water-butanol solvent extracts materials from flour in addition to the lipids. The chemical nature of these other substances has not yet been explored.

PROGRESS REPORT OF A LITERATURE SURVEY ON WHEAT CONDITIONING

M. M. MacMasters
Northern Utilization Research and Development Division

The literature on wheat conditioning has been carefully surveyed for the years 1927 to 1957, inclusive. A few important references before and after this period have been included in the survey. It will contain about 750 references, some of which are duplicates from different journals. Taking duplication into account, there will be over 650 references. The survey is being typed preparatory to review and publication.

Summaries of all data found have been prepared under the classifications: Cold conditioning; warm conditioning; hot conditioning (at temperature above 46° C.); steam conditioning, vacuum conditioning; conditioning by ultrasonic waves, high frequency current, electric condenser, and infrared rays; hygroscopicity of wheat; thermal properties of wheat; and water absorption by wheat.

Data on cold conditioning indicate that original moisture of the wheat and relative humidity of the air, rather than the amount of water added, affect evaporation from the stock during milling. Increased moisture content of the stock leads, on experimental milling, to lower flour extraction and increase in production of bran. This condition also has been reported to lower the resistance of kernels to crushing, decrease scouring loss, increase pearling loss, decrease tempering time, and effect a saving in power consumption. Cold conditioning of 48 hours has been recommended for Manitoba wheat, and conditioning for about 72 hours has been reported to permit obtaining the most break flour from hard wheat.

Warm conditioning usually was found to give results as good as or slightly better than those obtained by cold conditioning, as evaluated by cost, millability, and quality of flour produced. Different wheats require different conditioning.

In general, the data on hot conditioning show that treatment of various kinds of wheat at over 46° C. brought about an improvement in yield and/or baking quality of the flour, but different lots of wheat required different conditioning. Improvement of both overextensible and poorly extensible gluten has been reported to result from hot conditioning.

Steam conditioning of German domestic wheat resulted in better flour quality than was obtained when the wheat was unconditioned. Comparison of steam conditioning with normal and hot conditioning indicated that steam-conditioned wheat requires less power in milling, often gives higher yields of flour and coarse bran, and produces flour of

as high or higher quality than is obtained after other types of conditioning. One investigator reported improved millability of hard red winter wheat after steam conditioning but found no improvement of baking quality.

All reported benefits should be viewed with reservations, since different workers have almost invariably used different wheats, different details of conditioning, and different methods of evaluating the results. The complete data should be carefully studied by experienced millers before conclusions are drawn.

Discussion:

Coverage of Russian literature on wheat conditioning in the survey was limited due to the lack of translations of some longer articles. Translations of some short Russian articles were obtained through the courtesy of the Technical Committee of the Association of Operative Millers. The same situation prevailed in regard to Hungarian articles on wheat conditioning. The survey does cover all French, German, Spanish, and Portuguese publications for the survey period.

The question was raised as to whether the survey information on steam conditioning included data from this country, specifically data from operation of certain commercial steam conditioners. It was reported that numerical data on such results were not in the published literature. Most information for the survey on steam conditioners came from German literature.

Members of the milling group are in accord with two points made in the report of the literature survey. The American millers will not agree with all conclusions drawn by European millers because of differences in objectives and situations. Also, it is realized that numerical data are meager, and that data which are available usually are not intercomparable.

PRELIMINARY REPORT ON METHODS FOR DETERMINING MOISTURE DISTRIBUTION IN WHEAT KERNEL

M. J. Wolf
Northern Utilization Research and Development Division

A number of methods are being explored or are in the planning stage for determination of the distribution and localization of moisture in the wheat kernel after tempering.

With the interference microscope, the shift in wave-length phase introduced between two light beams when one beam is passed through a thin speciman may be measured. This phase shift, combined with the specimen thickness, may be used to compute its refractive index. Changes in refractive index are known to occur in the swelling of fibers and other plant materials following water uptake. Consequently the relation between change in refractive index and change in moisture content may provide a method for localizing the moisture. Average refractive indices of untempered wheat starch granules below 6 μ in horizontal diameter varied from 1.516 to 1.522. A large spread in the data indicated that thickness measurements, based on the assumption that wheat starch granules below 6 μ are approximately spherical, were in error. Significant differences due to variation in moisture content were not found in starch granules in this size range from Lee variety wheat.

Using polystyrene spheres as experimental material to help resolve difficulties due to thickness measurements, refractive indices were determined by two methods, (1) direct measurement of thickness, and (2) by use of two successive refractive index media without measurement of specimen thickness. Good agreement was obtained by the two methods; average refractive indices were 1.5934 $\pm$ 0.0020 and 1.5932 $\pm$ 0.0072. The spread in the data were considerably greater in the second method, possibly as the result of difficulty in replacing one medium with another.

Applying the double immersion method to Thatcher wheat starch granules containing 13 percent moisture and varying in horizontal diameter from 4 to 20 μ, an average refractive index of 1.5194 $\pm$ 0.0056 was found. More work with this method is required to increase its precision and to establish a relation between refractive index and moisture in starch granules. This work will also be extended to wheat cell walls and gluten.

In another approach to the study of moisture distribution in tempered wheat kernels, the iodine sorption method was used. Wheat was tempered either by direct immersion in water or by absorption of 2 to 10 percent of added water in a closed container. After standing for 30 minutes to 70 hours, the starch in cut surfaces of the kernels was treated with iodine vapor or by immersion of the

surface in mineral oil or silicone solutions saturated with iodine. On the basis of these data, water was found to enter the endosperm in the following time sequence: First, around the germ, second, at the brush end, and finally from all sides. Water was distributed throughout the endosperm within 70 hours. Up to 3 percent of added moisture was not detectable in the starch by this method even after 70 hours of diffusion. The added moisture is, however, recoverable by the oven method. A possible explanation of this anomaly is that components of the kernel other than starch absorbed the initial added water; starch may begin to take up water after the water-demand of cell walls and protein in the area has been satisfied.

Isolated starch shows detectable color development at 8 to 9 percent moisture content when iodine is added. Rate of color development may be accelerated by heat. Use of starch or flour containing definite amounts of moisture as color standards after treatment with iodine is being studied.

Application of tritiated water as a tracer to follow the distribution of water in the wheat kernel and to estimate the relative amounts present in various tissues is planned. The low energy of the beta particle emitted by tritium is readily dissipated in one or two collisions. This behavior favors detection of tritium radiation with a high degree of resolution by the method of autoradiography. Tritium exchanges readily with normal amino and hydroxyl hydrogens. It is anticipated that this exchange will pose a problem in the quantitative estimation of water distribution in the wheat kernel. It appears possible, however, to localize water distribution with tritium as a tracer, at least qualitatively, at the cell level.

CURRENT DEVELOPMENTS IN THE BAKING INDUSTRY

R. B. Meckel
International Milling Company

The baking industry has faced keen competition for the consumer's food dollar in recent years.

In a presentation in the August issue of FOOD PROCESSING, Mr. E. E. Kelly, Jr., president of the American Bakers Association, made several interesting points:

"From April 1953 until September 1957, our week-by-week tonnage reports showed that bread volume was running consistently ahead of the same week of the previous year, and well over the same week of our base year of 1954.

"Beginning last September, however, weekly tonnage reports started showing a drop to the year-ago level and below, indicating a drop in volume production." As Mr. Kelly pointed out in his article, this drop in volume production coincides with the recession period.

Continuing quote, "Per capita consumption of bread has shown definite increases. Whereas, year by year, population gains have been reported up 1.5 to 1.8%, our tonnage figures for these same years have shown gains from 2.5 to 3.2%."

The American Bakers Association reports that, "Estimates indicate that bread consumption holds at around four ounces, or five slices per day, since a slice averages 23 grams. This is bread in all forms,--white, dark, specialties, rolls, buns, partially baked breads, etc.

"This adds up to slightly more than 90 pounds per capita per year, or 14 billion pounds.

"Miller and wheat grower organizations have informed us the baker uses more than 155 million hundred-weights of flour annually, which is 76% of all flour sold domestically. This requires in excess of 350 million bushels of wheat."

The baking industry is making strides to greater economy through a number of avenues.

One of these is the bulk handling of ingredients, such as flour, sugar, and shortening.

In bread production, makeup technique has improved in relatively recent years. This has enabled the industry to produce bread with much better crumb characteristics.

Improved bun makeup technique has resulted in efficient, high-speed bun production.

Bread conveying techniques, to the slicers and away from the slicers, are much improved.

Under the heading of bread production, the Conventional procedure, the Liquid Ferment procedure, and the Continuous Mix process were compared and discussed at some length.

Continuous Mix process users and installations:

	Users		Under Installation	
	Bakeries	Units	Bakeries	Units
In United States	13	16	25	-
In Canada	1	2	4	5
In England	1	1	-	7

Under heading of packaging, distribution, and selling were discussed:

1. The baking industry is taking better advantage of the possibilities existing in its markets.

2. The industry is doing a better job of packaging or wrapping its products.

3. With the shift in grocery marketing from smaller to larger retail units, the baking industry is rapidly adjusting its efforts to get the greatest possible sales volume through the various types of larger markets.

4. In consumer education, American Bakers Association, in cooperation with American Institute of Baking, has been very active in publicizing the true food value of bread, and in eliminating false ideas about bread which are detrimental to the consumption of bread. One of their main efforts has been directed toward better exploiting the fact that the baking industry is spending large sums of money to fortify, or enrich, white bread with certain vitamins and minerals which are very important in human nutrition.

Discussion:

The main requirement in flour used in the continuous-mix process is good mixing tolerance. Flour with this characteristic is ordinarily not too difficult to obtain, but tolerance is a "must" under the conditions of "severe" mixing used in the new procedure. Mixing tolerance is probably about equal in importance in the conventional sponge process where high-speed mixers are employed.

Savings in the use of the continuous-mix process, which according to the manufacturer are substantial, result from the reduction in floor space requirements, ingredient-handling costs, and labor costs, and in the improved accuracy in scaling ingredients and dividing the dough. Equipment cost, including installation, is reported to be around $130,000.

The liquid ferment step is employed in the new process instead of the direct mixing of all ingredients because of the improved flavor introduced by a separate fermentation period. In discussing this point, it was speculated that the liquid ferment step might be eliminated if flavor constituents were known and could be added during the dough mixing operation.

Consumer response to white bread made by the continuous-mix process is reported by bakers using the procedure to be enthusiastically favorable. The process gives a good looking loaf with close crumb structure free of holes. A baking firm representative commented that a problem of the process was believed to be flavor, and also, that the staling rate of this type of bread should be investigated.

As far as is known, no whole wheat bread or other specialty breads are produced by the continuous-mix process.

The baking industry now produces 170-175 pounds of bread from 100 pounds of flour, while thirty or forty years ago this yield was 150-155 pounds per hundredweight of flour. Use of pre-ferments will provide an even higher bread-yield figure because 3 to 4 pounds of flour now are lost by conversion to alcohol and other volatile products during fermentation in the conventional sponge process. A trend toward the pre-ferment procedure would certainly not help to relieve the wheat surplus situation.

There appears to be no trend toward use of a higher ratio of dry milk solids in bread. The wholesale baking trade, at least, has held its rate of use relatively steady at 3 to 4 percent, based on the weight of flour.

THE CURRENT DEVELOPMENTS IN THE WHEAT FLOUR MILLING INDUSTRY

Stephen J. Loska, Jr.* and R. K. Durham
The Pillsbury Company

The application of air classification techniques to wheat flours is the most outstanding current development in the wheat flour industry. It represents an extraordinary scientific breakthrough, the full potential of which has not been explored fully. The interest in this field is not limited to the remarkable products which can be made, for air classification also provides a new method of physically subdividing flour, and we expect to gain greater knowledge of its properties.

Air classification provides an orderly, clear division of a number of flour parts which, despite some overlap of properties, broadens our understanding of flour. A practical division of both hard and soft wheat flours is possible which produces fractions, alone or in combination, which have economic worth equal to the parent or source flour. In addition, the new techniques provide better utilization of wheats, whose true potential or latent quality are hidden by the limitations of old processes, so that these wheats may hold their rightful quality rank or position.

Separations can be made of hard wheat flour so that one fraction is enriched in protein matter, a second and third fractions which are depleted of protein matter and lastly a fraction with enhanced bread baking properties by virtue of the removal of depleted protein fractions. Such separations can take many forms and the number of separate flours depends upon how keenly one wishes to express distinctions. A four-part separation according to flowdynamic size produces a small-size fraction of high-farinograph absorption, 78.7 percent in this case; two intermediate fractions of cake flour and pastry-cracker flour performance characteristics, and a coarse endosperm-chunk fraction. The coarsest fraction, endosperm chunk, can be blended with the high protein fraction to produce a superior bread flour, thereby taking advantage of the natural, good-baking properties of the fourth fraction and the strength and absorption augmentation of the fine high-protein fraction.

The two flours of low protein, separated from the hard wheat flour, can be classed as cake and pastry-cracker flours because of their protein levels and their functional or performance characteristics. Chemical and physical test data clearly indicate that these two flours are distinct entities despite the difference of about 1.0 percent protein. Study of the analytical data illustrate other properties which shift with the protein bearing material in this air classification example. Fat, high-maltose-value stock, high alpha-amylase, lipase and protease activity material shift with the high protein fraction.

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* Presented the paper.

A separation of soft wheat flour is described such that a high-protein fine fraction and two cake flour fractions were obtained. The high protein fine fraction contains 21.4 percent protein, in this case. A special purpose cake flour of 5.4 percent protein, which performs well in foam cakes and a secondary cake flour of 8.7 percent protein can be made. Blends of these two flours can be made which produce an 8.1 percent protein flour which when properly bleached shows extraordinary baking properties in high ratio cake formulas. Physical and chemical property differences for these three fractions were shown.

A very low protein content material with properties akin to wheat starch can be made in quantities to warrant consideration of this product as a food and industrial starch. Investigations are being made of the applications of this material and its potential economic worth.

Discussion:

An air-classified flour fraction with particle sizes in the range from 0 to 15 microns would contain a preponderance of protein. A fraction with particle sizes from 20 to 40 microns is mainly starch. Fractions above about 40 microns in particle size will be made up largely of "endosperm chunks," which consist of starch granules bound together by a matrix of protein much like that found in conventional flour.

It was reported that bake-shop absorption values for air-classified flours do not appear to correlate as well with farinograph absorption values as those for conventional flours. For the new type flours, high-protein flour shows lower absorption in the shop than on the farinograph, while low-protein flour shows higher. Bake-shop absorption in general seems to run higher with the new flours. It was also stated that bleach requirements were higher for cake fractions from hard wheat flour than for those from soft wheat flour.

High-protein fractions from hard wheat and from soft wheat are similar in properties, but they do exhibit some differences. This would indicate that some variation between the two in use could be expected.

A fraction low in protein, about 3 percent, can be obtained in practical quantities, and possible industrial and other uses for this product are being explored.

Advent of air-classification in the milling industry does not mean that present wheat quality concepts will be discarded. Some concepts may change, but probably not radically. One phase of the present version of variety selection is based on "static milling" capabilities. Since there has been no basic change in this initial

stage of the new milling procedure, variety selection for conventional milling quality factors will continue to be necessary. There may well be selection factors added which apply to ease and efficiency of starch and gluten separation for air-classification. Inherent character of original wheat is still very important processing-wise; in air-classification procedures, a good parent flour is needed from which to start.

Using the new milling procedure on soft wheat does not provide a means of making bread flour along with cake flour because a fraction suitable for bread flour is not left. However, soft wheat flours suitable for cake and cracker production are produced along with bread flour when hard wheat is milled.

Although the "line has been broken" between hard wheats and soft wheats in regard to traditional uses of their respective flours, one cannot at present predict large-scale changes in these use patterns. Possibilities from a research or a production standpoint appear good, but economics of transportation and of marketing all products from the new milling system is another matter.

WHEAT VARIETY QUALITY EVALUATION STUDIES

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Crops Research Division

The Crops Research Division conducts a national wheat research program of breeding, agronomic, disease, and quality investigations. It operates four regional wheat quality laboratories. They are located at Pullman, Washington; Manhattan, Kansas; Wooster, Ohio and Beltsville, Maryland. The first three are cooperative with the respective State agricultural experiment stations and the fourth is cooperative with Agricultural Marketing Service. Each is closely associated with the wheat quality problems of the area it serves. Work of the sort done in these laboratories is vital to the maintenance, stability and improvement of the quality of wheat grown in the U. S. This is so because wheat technology is not static. For instance, the dominant varieties grown on farms in 1958 were entirely different from those grown in 1954 in several large wheat areas. The new durum varieties Langdon and Ramsey, and the new hard spring varieties Selkirk and Conley, occupied nearly all of the acreage this year in North Dakota. In the Palouse, Omar replaced almost all other club wheat varieties. Knox, Dual, Vermillion, and LaPorte have taken over the acreage of soft red winter wheat in Indiana. Among hard red winters, Ponca has added materially to the quality of wheat in eastern Kansas, Oklahoma, and Nebraska, and Bison, introduced just three years ago, has been multiplied as rapidly as seed stocks permit and is receiving acclaim both from farmers and millers in Kansas and Nebraska. These changes were made without much, if any, disruption of traditional quality and indicate the importance and effectiveness of cooperation between the breeders and workers in the quality laboratories. Furthermore, the information gathered in these laboratories provided the principal facts for designating 33 varieties as unacceptable under the Government's price support program with the result that the acreage of these undesirables has dwindled to practically nothing.

The four laboratories have both practical and basic research functions as follows: (1) To evaluate and characterize prospective new varieties before they are released to farmers, (2) to cooperate with wheat breeders in the development of high quality new varieties, (3) to determine in cooperation with agronomists, pathologists, chemists, entomologists, and others, the influence of management practices and of genetic factors on wheat quality, (4) to ascertain the basic chemical and physical nature of differences among varieties and classes of wheat in milling behavior, bread-, cookie-, cake-, and macaroni-making qualities, (5) to account for environmentally induced quality variability and devise methods to detect and to overcome such deficiencies, and (6) to design more accurate or precise, new or

improved methods of measuring quality differences for more effective varietal characterization in plant breeding and genetic work.

Every year about 2,000 variety samples, submitted by plant breeders, are given full evaluation in the laboratories. In addition, an even larger number of samples is given single quality tests, micro tests for the most part. The thimble mill, for example, developed at Pullman, was used to evaluate 32,000 samples in the 1956 and 1957 seasons. As better tests are developed it is possible to mass evaluate populations developed by plant breeders.

General evaluation for quality has very little specific usefulness to plant breeders and almost none for geneticists. Therefore basic research to develop an understanding of each quality component is emphasized in the basic research done in these laboratories. Short-cuts to quality determination are a byproduct of this research.

Recent research in the laboratories has resulted in developments on methodology and on basic factors influencing quality including the following:

- A new five-gram milling-quality test for use in wheat breeding.
- Micro flour quality tests.
- Estimation of protein in wheat and flour by ion-binding.
- Interactions between proteins and polysaccharides of wheat flour.
- The intrinsic viscosities of the water-soluble components of wheat flour.
- Evaluation of flour fractions for their importance to cookie quality.
- Cake and cookie flour fractions affected by chlorine bleaching.
- A lean formula cake method for varietal evaluation.
- Flour particle size and cookie quality.
- Effects of the water-soluble constituents of wheat flour on cookie diameter.
- Changes in cookie doughs upon heating.
- Estimating starch tailings.
- Effect on loaf volume of high temperatures during the fruiting period of wheat.
- Effect of foliar spraying of Pawnee wheat with urea solutions on yield, protein content, and protein quality.
- Quality characteristics of two pairs of isogenic lines of wheat.
- Further developments in the sedimentation test for wheat quality.
- Infrared spectra of wheat flour protein.
- The relationship of types of phosphorus in wheat flour and gluten to flour quality.

EFFECT OF VARIETY AND MALTING CONDITIONS ON ALPHA-AMYLASE AND PROTEASE ACTIVITY

John A. Johnson
Kansas State College

Utilization of malted wheat by the baking industry has declined significantly since the advent of fungal enzyme production. This loss of market was due to the industry's growing need for enzyme supplements possessing higher protease activity. This study was made to investigate factors affecting the production of alpha-amylase and protease enzymes in malted wheat.

Both enzymes increased with germination time during malting. The elaboration of enzymes was rapid up to the sixth day; thereafter the rate decreased. Increasing steep moisture to as high as 46 percent increased enzyme activities. Above a steep-moisture level of 42 percent, time and losses in malting yield become critical factors. Enzyme activities increased as the germination temperature was increased up to 68° F. Malting loss and mold growth become excessive above 62° F. Increasing kilning temperature decreased the enzyme activities, protease being more susceptible to inactivation than the alpha-amylase. A kilning temperature of 104° F. was the lowest practicable.

Freshly harvested wheat manifested dormant characteristics for the first two months of storage at 40°, 80° or 100° F. Storage at lower temperatures favors production and retention of high enzyme activities in the malted wheat.

Soft white wheats as a class generally produced more enzymatically active malts than soft red winter wheats. Hard red winter wheats were somewhat superior to durum wheats, while the hard red spring wheats were the least desirable. Selection of class of wheat for malting purposes will be dictated by price differential. Considerable varietal difference within wheat classes was noted.

Environment under which the wheats were grown was also an important factor. Protein content of the wheat was not consistently correlated with enzyme activity of the malt. If environment caused low test weight, a low enzyme activity and low malt yield could be expected.

Preliminary evidence suggests that mold development during germination and elaboration of enzymes may be accelerated by the use of gibberellic acid.

ELECTROPHORETIC ANALYSIS OF WHEAT GLUTEN

R. W. Jones
Northern Utilization Research and Development Division

Previous attempts to determine the number of components in wheat gluten have met with little success. Perhaps the most definitive method of resolving such a problem is through the use of electrophoresis. In the case of wheat gluten, special difficulties are encountered because of the insolubility of gluten in conventional electrophoretic buffers. Electrophoretic patterns of wheat gluten previously reported in the literature are asymmetric with respect to the ascending and descending boundaries. The number of peaks in such patterns do not necessarily represent the number of components in the protein being studied. Preliminary objective of the present work was to find electrophoresis conditions which would give symmetrical diagrams, because such patterns would aid in establishing the number of components in gluten and their relative concentrations. An analytical tool also would be provided for following the progress of gluten fractionation experiments. Lack of such a tool has been a handicap in previous attempts to fractionate gluten.

Several suitable buffer systems have been found. They include sodium chloroacetate-chloroacetic acid, sodium acetate-hydrochloric acid, sodium phosphate-phosphoric acid, all at pH 3.1 and nominal ionic strength of about 0.03, and aluminum lactate-lactic acid at pH 3.1 and nominal ionic strengths of 0.03 to 0.12.

Electrophoretic patterns obtained in these buffers demonstrated that gluten of bread wheats is composed of at least 4 major and 1 minor component representing, in order of decreasing mobility, relative concentrations among themselves of approximately 44, 22, 15, 16, and 3 percent. There is evidence that the peak containing 15 percent of the total gluten is composed of two components. In additional, the patterns show the presence of a small amount of relatively fast-moving material which is believed to be globulin or albumin rather than true gluten protein.

While aluminum lactate-lactic acid buffer does not resolve the two faster moving components, the excellent symmetry of the patterns obtained in this medium at relatively high gluten concentration recommends its use for following the progress of fractionation experiments and for investigating the effect of such variables as gluten quality and method of preparation on gluten composition. A partial separation of the electrophoretic components has been obtained by precipitation of gluten from acid solution by increasing pH or ionic strength. The relationships of electrophoretic pattern to gluten quality and to method of preparation have also been studied.

Discussion:

Further information regarding gluten fractionation studies brought out in discussion included details of pH. The practical range covered in these studies began at 3.0 and extended to around 4.8, where precipitation of some components started. Within this range, about the same fractionation results were obtained regardless of pH. At higher values, 7 or above, gluten broke down giving off hydrogen sulfide due to the breaking of disulfide bonds under alkaline conditions.

Heating gluten in dilute acetic acid solution to inactivate enzymes causes no precipitation of the gluten. In the heating step, the solution is brought to 98° C. momentarily, then quickly cooled. Total nitrogen loss, about 5 percent, occurred during centrifuging prior to the heating step.

Areas under the peaks of the electrophoretic pattern were found to give quantitative values. In tests where all data, including those on albumins and globulins, were totaled, recovery was nearly quantitative.

Glutenin was found to be related to the leading component in the electrophoretic pattern, while gliadin remains as a mixture of the various newly recognized components.

Electrophoretic differences can be noted between durum wheats and bread wheats, spring or winter, but no such differences are seen between good and bad baking quality wheats. There is hope that additional work will permit further characterization of the glutens.

CHROMATOGRAPHIC SEPARATION OF PROTEINS IN WHEAT GLUTEN

J. H. Woychik
Northern Utilization Research and Development Division

In order that a more definitive study of the structure and properties of wheat gluten can be made, it is first necessary to obtain a method whereby the gluten complex can be resolved into fractions more distinct than those obtained by the classical fractionation into glutenin and gliadin. Through the use of an aluminum lactate buffer system, gluten has been shown to yield four electrophoretic components. Studies on the separation of gluten into fractions corresponding to those electrophoretic components are reported in the present paper.

The gluten proteins were readily adsorbed from solution in dilute acetic acid by carboxymethylcellulose (CMC). Attempts to desorb the gluten proteins by elution at increasing pH values or ionic strengths failed because of precipitation of the proteins in the column. Successful desorption was accomplished, however, by gradient elution with increasing hydrogen ion concentrations. While the optical density curves (280 mμ) showed no appreciable resolution of the proteins into chromatographic peaks, the proteins were eluted in the order of increasing electrophoretic mobilities. Displacement with stepwise rather than continuous increases of hydrogen ion concentration resolved the proteins into fractions, each consisting primarily of a single electrophoretic component. Rechromatography further separated the gluten proteins into reproducible fractions of high purity. In this manner, four fractions were obtained which corresponded to the electrophoretic components exhibited by gluten in the aluminum lactate buffer system.

The availability of wheat gluten fractions corresponding to observed electrophoretic components presents the opportunity for a more definitive study of these proteins. Their further study will include amino acid composition, sedimentation analysis, viscosity determinations, and other studies which will contribute to our knowledge of wheat gluten, thereby permitting further utilization of this unique protein.

IMPROVED PROCESSING METHODS FOR FRACTIONATION OF WHEAT FLOUR AND MANUFACTURE OF VITAL GLUTEN

Roy A. Anderson
Northern Utilization Research and Development Division

The per capita use of wheat and wheat flour for food products has been declining steadily for many years. Only through the increase in the country's population has total consumption of wheat as food been able to maintain its more or less constant level. At the same time our capacity for producing wheat has increased tremendously. It is apparent that the wheat surplus will not disappear due to human consumption; other outlets must be sought. A potential outlet for utilization of some of the surplus wheat would be in industrial products. This use could be implemented by converting wheat or wheat flour into industrially attractive raw materials.

Wheat flour may be fractionated quite readily to yield gluten, starch and a soluble fraction. Wheat gluten is an unusual protein, having many physical and chemical properties not found in any of the other cereal grain proteins. Wheat starch can be easily fermented, or converted into syrup and sugars. The soluble fraction, containing a number of proteins and sugars, could find use as a fermentation medium adjunct.

Pilot-plant studies have been carried out, directed toward improvement of the laboratory developed "batter process" for separating gluten and starch from flour, and also toward development of a new and simple method of drying wheat gluten, so that a vital product is recovered.

A continuous pilot plant for carrying out the batter process has been designed and constructed from conventional equipment. The operation of the plant is flexible. It is believed that commercial application could be made by a relatively simple scale-up of equipment. Flours milled from different types of wheat have been processed successfully in this plant. In most cases, the recovery of protein in the gluten has been greater than 80 percent, with the gluten purity also about 80 percent.

Operation of the process has shown it to be easily controlled and amenable to instrumentation, thus it can be carried out with minimum requirements for labor, power, and water. The process yields products of uniform quality and composition. It is estimated that the cost of processing one pound of flour to starch liquor and wet gluten by this method would be 0.27 cents.

A process has been developed for preparing dry vital gluten by atmospheric drum drying of wet gluten dispersed in dilute acid. The wet gluten from the batter process is completely dispersed

in dilute acetic acid to form a suspension with a pH in the range of 4.5 to 5.1 and containing up to 20 percent solids, then fed to an atmospheric drum-dryer heated with steam in the range of 20-80 p.s.i.g. The resulting dry material is pulverized to a size suitable for subsequent use.

Glutens prepared in this manner from a variety of different flours and drum-dried possessed good quality, which in most cases, compared quite favorably with that of vacuum dried gluten. A gluten product light in color and weight is produced by the new process. The plant production cost for carrying out this process is estimated at 4 cents per pound of dried gluten produced.

Discussion:

The question was raised as to whether any difficulty is encountered in the continuous batter process in obtaining gluten in suitable curd form. It was reported that a little difficulty is met in processing soft wheat flours, also certain other flour fractions with ash up around 2 percent. The process can be altered to accommodate these materials satisfactorily. Agglutination is satisfactory with second clears.

With ground whole wheat, no agglutination is obtained, however, removal of bran improves curd formation.

Untreated flours only have been used, mainly first clears. Materials processed satisfactorily have included patent and other flours higher in ash used in the bakery trade. No tests were made of the effects of bleaching on processing results.

GENERAL DISCUSSION PERIOD

State Wheat Groups:

At the beginning of the general discussion period, members of the State wheat organizations present were invited to contribute comments.

Mr. Graber, Administrator for the Kansas Wheat Commission, stated that his group is interested in wheat utilization. Efforts of the Kansas organization has been mainly toward strengthening foreign markets for Kansas wheat as the more immediate means to alleviate surplus. His group's knowledge of research work in utilization is limited, but the Kansas Wheat Commission will support utilization research or any project which will help to use more wheat at home and abroad. Mr. Graber expressed the hope that the State wheat organizations will have the opportunity to attend future meetings.

Mr. Sheffield, Chief, Division of Wheat Development, Nebraska, said his group looks to industrial utilization of wheat as a long-range, expensive but necessary objective, with perhaps some difficulties ahead of it. The Nebraska Wheat Commission has been trying to get started on utilization research projects, but in the three years the organization has been in operation, the only practical project underway in utilization is one on feeding of beef. The wheat disposal problem is big. The country's past 10-year average production of wheat has been about 1.1 billion bushels grown on 65-70 million acres. This year, it looks like 1.4 billion bushels on about 55 million acres. After allotting 600 million bushels for domestic use, there will be a 800-million-bushel disposal problem from this year's crop alone, a quantity much too large for our foreign markets. Dollar shortage complicates the foreign market picture; in this regard, Public Law 480 has been a valuable aid in disposing of wheat abroad. Nebraska is an area of high wheat production, far from the main markets. Transportation costs are high, and the State is already faced with a big wheat storage problem. The Nebraska Wheat Commission is very willing to cooperate in any way to increase use of wheat, and will be glad of any opportunity to support utilization research on it.

Mr. McCormick, Director of the Colorado Wheat Administrative Committee, commented that the State wheat people were at the present meeting to learn about utilization research on wheat. The Colorado wheat organization is newly established, and is closely allied with the Kansas and Nebraska Wheat Commissions. McCormick expressed the desire of his group to cooperate in any way possible to increase use of wheat.

Problems for Research:

The meeting was thrown open to research suggestions from those present covering any phase of wheat utilization. These suggestions are summarized below.

Fundamental--Of most concern to the wheat processing industry is the need for better basic knowledge of gluten. More fundamental studies are needed on structure and chemistry of gluten, and on the role of minor constituents in wheat protein chemistry. Informational needs in all areas of wheat utilization,--food, feed, and industrial--would be helped by more complete fundamental data on all constituents of wheat. Such information could aid greatly in development of badly needed tests, simple and rapid, that can evaluate flours in numerical rather than descriptive terms.

A specific area of needed information relates to differences in constituents in hard red winter and hard red spring wheats that account for differences in baking performance. This is only a part of the over-all problem of understanding fundamentals of protein quality differences in all flours and all wheats, a problem still unsolved.

Industrial--The air-classification process in the milling industry opens new horizons in terms of novel products from wheat and other cereal grains which may have great potential as raw materials for industrial use. Properties of these new materials should be studied.

Food--Further studies are needed on the role of lipids and proteins in baking, and the influence of minor constituents on baking performance.

More information on nutritional factors in white bread is needed on which can be based educational programs to advertize value of bread as food. Development of totally new foods from wheat, with high palatability and wide consumer appeal, is needed to increase utilization of wheat as food.

Investigation of technical and economic factors in frozen preservation of baked goods should be continued to insure safeguarding fresh-baked quality for the consumer.

Feed--Increased production capacity along with decreased market for millfeeds presents a real problem for the milling industry. Raw material cost is too high for industrial use of feed-type products. There is need to emphasize research on the cause of poor growth response from millfeeds in poultry and other rations.

Milling--Advent of air-classification in milling means that lack of fundamental information on wheat conditioning will be even more critical; millability and separability will be closely related to tempering efficiency. Research on wheat conditioning should be intensified.

SUMMARIES OF LABORATORY TOUR TOPICS

At the conclusion of the conference sessions, participants were taken to locations in the Laboratory where several products, procedures and equipment related to wheat utilization research were demonstrated.

Chemical Modification of Wheat Flour--Charles R. Russell, Northern Division

Industrial utilization of cereal flours in applications other than those pertaining to food or feeds has been decidedly limited because of the unsatisfactory flow properties of cereal flour pastes. Since etherification with reagents such as ethylene oxide has been used to advantage to modify properties of starch and cellulose, an investigation of the modification of properties of wheat flour with such reagents has been undertaken. Thus far this has resulted in development of a simple low-cost method for the hydroxyethylation of wheat flour. In this process, commercial wheat flour containing approximately 14 percent moisture is thoroughly mixed with 2.5 percent dry, powdered sodium hydroxide and allowed to age at room temperature for four days. During mixing, in a closed kneading machine, ethylene oxide is then added to the aged alkaline flour until the desired level of substitution is achieved. Products containing combined ethylene oxide from a few percent up to 20 percent by weight are readily prepared by this method.

These products are not only more readily dispersed than the unmodified flour but have increased viscosity; the tendency for their dispersions to retrograde is reduced considerably. These improvements in dispersions and flow properties should afford new opportunities for industrial utilization of wheat flour.

Preliminary studies with propylene oxide have shown that this reagent may likewise be used to advantage in modifying the properties of wheat flour.

Bulgurs as New Wheat Foods--James Pence, Western Division

As examples of developments designed to spur a faster and wider acceptance of wheat in the form of bulgur products by domestic households, the Western Division exhibited quick-cooking dry bulgur and canned precooked, whole-grain bulgur, together with pilafs prepared from them. The traditional cracked bulgur is a dry product requiring a minimum of 20 minutes to prepare for serving. The quick-cooking product exhibited requires 3 minutes or less for preparation. The canned bulgur also can be prepared for serving in 2 or 3 minutes, and its whole-grain form very likely will promote a wider and more ready acceptance by consumers, based in part upon connotation of higher nutritive value of whole-grain products. The pilafs prepared from each type of bulgur are examples of a number

of ready-to-eat dishes that can be prepared from bulgurs for commercial distribution. Quick-cooking, precooked, or traditional forms of bulgur fit well enough into the general types of cooking in all parts of the country that a greatly expanded use would seem to depend principally upon suitable national promotion. For example, in regions where it has already been promoted, bulgur has been readily accepted as a substitute for wild rice in poultry stuffings. Other common uses are as an accompaniment for meat dishes, as a meat extender, breakfast cereal, and in soups, gravies, and puddings.

Electrophoresis of Wheat Gluten--N. W. Taylor, Northern Division

A demonstration was made of the electrophoresis machine used in the study of gluten composition. An assembled cell was also displayed. The pattern of a gluten preparation in standard aluminum lactate buffer was observed directly in the machine and was compared with photographs of patterns of fractions of gluten to demonstrate the use of electrophoresis as a tool in separating gluten into its components.

Labeling Organic Compounds from Farm Commodities with Tritium--J. C. Cowan, Northern Division

Tritium, a radioactive heavy isotope of hydrogen, has several advantages as a labeling atom in tracer work with organic compounds, less risk due to lower energy and low relative cost being two such advantages.

Organic compounds, for example wheat germ oil, can be tritiated by being shaken (if a solid) or rotated (if a liquid) for 10-15 days in contact with tritium gas in a sealed glass tube. If a fatty acid, such as oleic acid, from the wheat germ oil is to be studied, the tritiated material is removed from the sealed tube and the labeled oleic acid obtained following a series of chemical operations. By study of the oleic acid's radioactivity and by various other operations including liquid and gas chromatography, thermoconductivity, and oxidation, much can be learned about the manner in which tritium has reacted with oleic acid in wheat germ oil.

Mr. Selke demonstrated the Tri-Carb liquid scintillation spectrometer, outlining the procedure by which tritium atoms in oleic acid, in decomposing to helium plus electrons, would be measured. The electrons are absorbed by the diphenyloxazole (POP), emitting ultraviolet light. This in turn is absorbed by bis-phenyloxazolylbenzene (POPOP) to give visible light. The flashes of light are counted by balanced photoelectric tubes, and recorded through the scaler, analyzer and brain onto the tape of a standard adding machine. A part of the counting equipment, including a turntable and photoelectric tubes, are housed in a deep freeze in order to reduce thermal noise. One hundred samples of tracer materials can be counted in 150 minutes.

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Service

Northern and Western Utilization Research and Development Divisions
Crops Research Division
Technical Advisory Committee, Millers' National Federation

THIRD ANNUAL
WHEAT UTILIZATION RESEARCH CONFERENCE
at
Peoria, Illinois
September 30 - October 1, 1958

List of Attendance

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3. C. E. Rist
4. F. Fuehrer
5. M. J. Dahl
6. J. S. Kelley
7. W. D. Maclay
8. Betty Sullivan
9. B. Grogg
10. J. W. Pence
11. W. C. Shuey
12. I. H. Hunter
13. M. C. McCormick
14. R. H. Roark
15. W. G. Bechtel

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16. W. L. Heald
17. T. A. Rozsa
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19. C. L. Mehltretter
20. K. A. Gilles
21. W. L. Rainey
22. G. E. Findley
23. H. G. Obermeyer
24. W. K. Trotter
25. H. J. Loving
26. D. L. Miller
27. R. K. Durham
28. O. A. Oudal
29. J. S. Whinery
30. W. R. Wichser
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32. L. Zeleny
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35. M. C. Harris
36. H. C. Nielsen
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41. J. W. Giertz
42. H. C. Becker
43. H. E. Smith
44. J. J. Schumacher
45. J. C. Rankin

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46. R. J. Dimler
47. M. J. Wolf
48. Dorothy Bradbury
49. S. M. Schwartz
50. R. G. Garner
51. C. E. Schmalz
52. H. L. Seckinger
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58. K. R. Powell
59. C. R. Russell
60. W. C. Witham
61. L. P. Reitz
62. L. F. Sheffield
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64. J. J. Spiruta
65. R. E. Brown
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67. R. J. Anderson
68. R. A. Anderson
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71. N. W. Taylor
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73. E. L. Griffin
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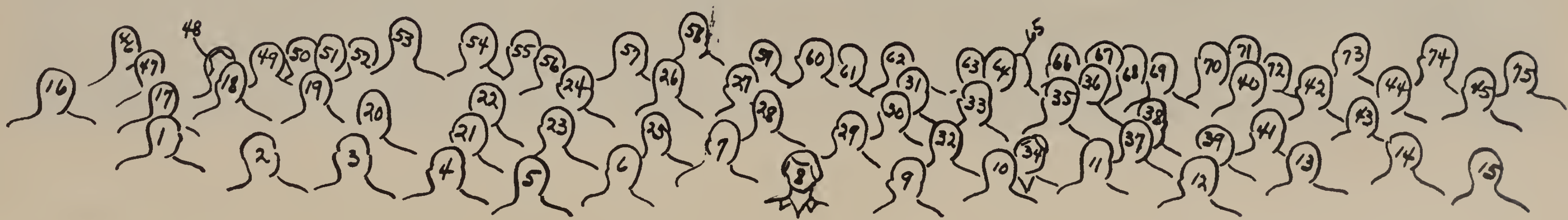
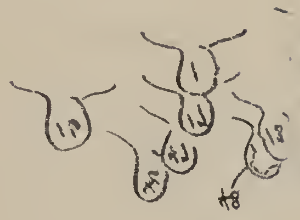
LEGEND FOR GROUP PHOTOGRAPH





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2. D. K. D
3. C. E. K
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5. M. J. D
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7. M. D. W
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14. R. H. R
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NORTHERN REGIONAL LABORATORY